

CHAPTER ONE

GENERAL

**BUREAU OF DESIGN AND ENVIRONMENT
SURVEY MANUAL**

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CHAPTER ONE

GENERAL

I. INTRODUCTION

A. PURPOSE OF MANUAL

The Illinois Department of Transportation Surveying Manual has been written to present a unified plan for surveying functions and their relationships to other functions and divisions within the Department. The Manual contains material that is of both an informational and instructional nature. Guidelines and procedures are spelled out in detail in the hope that greater uniformity and quality can be attained in surveying activities in and for the Department.

The intent of this manual is to provide the surveyors and engineers with an outline of the methods which should be utilized to procure the data necessary to locate a highway improvement and prepare construction plans. It is essential that all data collected be accurately recorded so design plans match the actual field conditions.

B. SURVEYING CLASSIFICATIONS

B.1 Route Surveying

Route surveying is a branch of surveying concerned with fieldwork and calculations necessary to fix the line and grade of proposed routes of transportation and communications.

Generally, route surveying may be accomplished by employing either ground or aerial surveying procedures and techniques, or a combination of both. Ground surveying policies and procedures are discussed in the chapters relative to the type of survey being done.

B.2 Cadastral Surveying

Cadastral surveying deals with the laying off or the measurement of lengths and directions of lines forming the boundaries of land or real property. Cadastral surveys are made for one or more of the following purposes:

- To secure the necessary data for writing legal descriptions and for finding the area of designated tracts of land.
- To reestablish the boundaries of a tract for which a survey has previously been made and for which the description is known.
- To subdivide a tract into two or more smaller units in accordance with a definite plan which determines the size, shape, and location of the units.

Whenever real estate is conveyed from one owner to another, it is necessary to know and identify the location and boundaries of the land conveyed within acceptable limits of certainty. Land acquired for highway improvements changes ownership from private owners to the State of Illinois. Private property owners thus become the neighbors of the newly constructed highway facilities. The maintenance of good relationships with these neighbors is a prime concern of the Department.

II. SURVEY PERSONNEL

Personnel requirements and the composition of a survey crew will normally vary depending on the type of survey to be performed, the topography involved, and the preference of the individual surveyor. For these reasons, it is inappropriate to establish specific guidelines relative to the makeup of a particular survey crew. However, in most instances, a ground survey crew should consist of at least a crew chief, instrument person and two rod-persons/chain-persons.

The designated leader or crew chief is responsible for organizing the crew, securing the transportation and equipment necessary, and providing for the safety of both the survey crew and the traveling public. He/she is also responsible for the proper use and care of vehicles and equipment assigned to the crew.

III. TYPES OF SURVEYS

Generally, the Division of Highways employs six types of surveys in the process of locating, designing and constructing a highway facility on a new location. These are identified and discussed in subsequent paragraphs.

A. CONTROL SURVEYS

Control surveys are surveys accomplished using procedures for first, second or third order work. They are used to provide first or second order horizontal and third order vertical positional data for the support or control of subordinate surveys.

B. LOCATION SURVEYS

Location surveys are general surveys of two or more feasible corridors. These surveys are performed by Department personnel or consultants, and consist of studying large scale (1:2400) topographic maps that have contour intervals of 5.0 feet or larger. These maps are normally prepared from aerial photography.

C. DESIGN SURVEYS

Design surveys are detailed route locations. These surveys establish the final alignment of the route and provide designers with accurate and specific data required to design the various elements of the proposed highway and to incorporate them into contract plans. [See Chapter Three](#) of this manual for Design Survey requirements.

D. LAND SURVEYS

Land surveys tie in all land lines and land corners, so as to draw plats of surveys, whereby land is purchased. Details are covered in [Chapter Five, Land Surveys](#).

E. CONSTRUCTION SURVEYS

Construction surveys are basically the transfer of plan details to field staking. The procedures for this transfer are covered in [Chapter Six, Construction Surveys](#).

F. PHOTOGRAMMETRIC SURVEYS

Photogrammetric surveys are surveys that provide location and/or design survey data acquired from aerial photography. [See Chapter Four](#) for the procedures to perform control work for a photogrammetric survey.

IV. EQUIPMENT

The Division of Highways has a considerable investment in survey equipment, which is available to survey crews.

Global Positioning Systems (GPS), total stations, electronic distance measuring equipment, electronic bar code levels, tapes, range poles and various accessories are available for measurement of distances, angles and elevations.

GPS equipment is available for establishing first order horizontal control and third order vertical control.

Transits and theodolites are available for maintaining a straight line during measurements or for angle measurements. The accuracy desired will normally dictate which instrument should be used for a given situation. Standard range poles or small poles on top of prism housings are normally used as sights on angle stations.

Levels, hand levels, level rods, direct reading rods and twenty-five foot (8 meter) long fiberglass telescoping rods are available for use by level crews. Direct reading rods are not considered particularly advantageous for cross sectioning. The twenty-five foot (8 meter) fiberglass rods are extremely useful in difficult terrain for some operations. They are not acceptable for precise leveling.

Other equipment, although not specifically identified as survey equipment, is necessary for the proper functioning of a survey crew. Equipment in this category includes vehicles, two-way radios, portable computers, portable roadway warning signs, brush cutting equipment, safety vests, ball caps, etc.

V. FIELD NOTE RECORDING

A. GENERAL

The end product of the field survey is the set of notes, which is returned to the office. For this reason, no phase of the surveyor's work is of greater importance, or requires more careful attention than keeping the field notes. The quality of the entire survey is directly reflected in these records. They shall be permanent, legible, and complete and convey only the intended interpretation.

In order that the notes are permanent, they shall be recorded with a fairly hard (3H or 4H) drawing pencil with a sharp point. In accordance with good surveying practice, an incorrect value, once recorded, shall be lined out rather than erased. In order to have field notes legible, they shall be lettered rather than written. The lettering shall be of such size as to permit a reasonable amount of data to be entered on a page without

crowding. A further discussion of the manner in which topography and cross section notes should be recorded will be [found in Chapter Three](#).

As the notes are placed in the field book, the Division of Highways acquires a very sizeable investment in the book. Everyone involved in handling these books is cautioned that great care should be taken with these books. The field notes generally represent the only record of the survey crew's activities and their replacement cost would be considerable. Every reasonable precaution should be taken to insure the safety of the field books.

B. TYPES OF RECORDING MEDIA

B.1 Book Size

Various types of field books are available; however, by far the most common are the 4½" x 7¼" (114 mm x 184mm) and the 8½" x 11" loose leaf paper (213 mm x 276 mm) sizes. In the interest of uniformity, all field books prepared by or for the Division of Highways should be prepared in either of these size books. The binding should be of canvas or imitation leather and the paper should contain at least 50% high-grade rag stock with a water resisting surface. There should be five red vertical guide lines on the left side for leveling or cross section notes and one red vertical guide line on the right side for topography notes.

B.2 Duplicating

"Duplicating field books" are also available to the above specifications and may be used where applicable. The most common use of "duplicating books" is where the notes must be sent to another agency or office. Some consultants use this type of book in order to retain a record of their notes after the penciled field books have been turned over to the Department.

B.3 Loose Leaf

When loose leaf field books are used, notes may be sent to the office daily or weekly and at the same time allow the field crew to add new data to the books. However, the use of loose-leaf field and paperback notebooks is not preferred. In both cases, the poorest feature is the lack of permanency, which is one of the prime requisites for survey notes.

B.4 Magnetic Media

When magnetic media is used to electronically collect and record survey data, the computer files shall contain the raw and processed data. Included with the diskettes should be a list of file names, a description of each file on the

diskette(s), the software package used and the version number. For more detailed information on electronic survey data requirements, [see Appendix B](#) of this manual.

C. INDEXING

Before starting to record notes in a new field book, place a notation on the first leaf of the survey book requesting that if the book is found, it should be returned to the District Engineer whose name and address is therein given. To assist the user of the survey book, a map showing the location of the survey may be pasted on the inside of the front cover.

On the second sheet of the book, the names of the various persons in the crew, together with the position that each person occupies, shall appear. The date of the beginning of the survey is also required. The route, section, county and state job number shall also be shown. Number the double pages in the upper right hand corner throughout the book. Leave several blank pages in the front of the book in addition to the pages used for the information mentioned above. It is well to leave a half dozen or so pages at the back of the book for additional data that may be required later. Provide the date and weather conditions on the page that begins each day's work.

When the notes in the field book are completed, place an index on the first of the blank sheets that were left in the front of the book. If the book contains level notes, they shall be checked in the field and a note placed on the very last page indicating the name of the checker and the date. Similar notes shall be made when the centerline elevations and grade rods are computed and checked. On topography notes, the curve data shall be checked and a similar note made.

At times, one of the most difficult tasks in interpreting a field book is determining how the survey began. This information shall be placed on one of the early pages and may require a paragraph of explanation sketches and perhaps cross-references to data on other pages in the book. This information shall indicate what datum has been used (i.e. the National Geodetic Vertical Datum of 1929, the North American Vertical Datum of 1988, or the North American Datum of 1927 or 1983) and whether the stationing is new, a continuation of previous stationing or arbitrary stationing.

VI. FIELD COMMUNICATIONS

A. PROPERTY OWNER CONTACT

Members of a survey crew are usually the first representatives of the Department to have personal contact with property owners and/or tenants along the route of a proposed improvement. The impressions they leave will reflect on the Department, and could affect the relationship of right of way or construction personnel in the future.

A.1 Verbal

Prior to entering any private property, the crew chief shall contact the owner and/or tenant and explain the purpose, nature and approximate duration of the proposed work. However, he should refrain from outlining any plans or policies that might be misconstrued. Record personal contacts carefully and accurately for future use. As a minimum, the record should include the names of persons contacted, identifying them as owners or tenants, the date and time of conversation, and a synopsis of the conversation. Telephone numbers for future contact are especially useful.

A.2 Written

Verbally advising a property owner or tenant of the time and reason of any proposed entry on his property will normally suffice. However, it may be advantageous to notify owners of property in highway corridors in writing well in advance of a pending survey or soil sampling expedition. The written notification shall include the assurance that the Department guarantees reimbursement for any damages to the property or crops, which may be attributed to the entry of Department personnel. [Figure 1.1, page 1-16](#) illustrates a sample letter that may be used for notification.

B. RIGHT OF ENTRY

B.1 Right to Enter

Survey crews, as representatives of the Department, have a right to enter upon the lands or waters of any person, after the owner has been notified; however, such entry is subject to responsibility for all damages which may result from such entry. See 605 ILCS 5/4-503 of the Illinois Compiled Statutes, or Chapter 121, Section 4-503 of the Highway Code, which states:

“For the purpose of making subsoil surveys, preliminary site investigation for hazard substances, preliminary surveys and

determinations of the amount and extent of such land, rights or other property required, the Department, or any county, by its offices, agents or employees, after written notice to the known owners and occupants, if any, may enter upon the lands or waters of any person, but subject to responsibility for all damages which shall be occasioned thereby.”

B.2 Denial of Entry

In cases where the owner denies a survey party entry to his property, a formal notification letter, making reference to the specific statutes should be sent to him/her by registered mail from the district office. If the owner still refuses entry or challenges the right of entry after receipt of the registered letter, the local law enforcement agency shall be contacted for assistance in gaining entry.

B.3 Damage Claims

To facilitate settlement of any claims for damage, to property or crops, which may be attributed to the activities of a survey crew, the crew chief shall annotate any unusual conditions that exist on entry to and departure from any private property. If it is anticipated that a claim may be filed for damages, the crew chief shall report noted conditions to his/her office as soon as possible.

VII. PLANNING

A. GENERAL

When a crew chief receives a survey assignment, he/she must classify the survey as to type. Survey types are described in [Section III, page 1-2](#) of this chapter. Having classified the type of survey required, a list of source data can be made. Source data provides information needed to locate, reestablish and evaluate data needed to produce the survey information required of the specific type of survey.

B. SOURCES OF DATA BY SURVEY TYPE

B.1 Control Survey

To perform a control survey, research of all existing recorded horizontal and vertical monumentation shall be investigated. Following is a list of source data for control surveys.

B.1.1 National Geodetic Survey (NGS)

The National Geodetic Survey is a federal agency responsible for the establishment and maintenance of first and second order horizontal and vertical control. If control cannot be found in local files, the Illinois Geodetic Advisor can be contacted at 217/524-4890 in the Aerial Surveys Office in Springfield.

B.1.2 U.S. Geological Survey (USGS)

The USGS is a federal agency responsible for providing small-scale topographic mapping. Control established by this agency is surveyed to second and third order standards. Each district office should have a copy of information covering their district.

B.1.3 Illinois Department of Transportation

IDOT files shall be checked to investigate the horizontal and vertical control that may have been established by previous IDOT surveys.

B.1.4 Corps of Engineers

The Corps of Engineers is a federal agency responsible for providing control and mapping along the major rivers. Control established by this agency is of the second and third order magnitude of accuracy.

B.1.5 Other Sources

Contact local survey firms to inquire about any control they may have established in past surveys.

B.2 Land Surveys

To perform a land survey, research of the following public records is required to provide the surveyor with adequate information to evaluate land ownership and right of way lines.

B.2.1 Construction Plans

Obtain existing highway construction plans that show the right of way, centerline stationing and control used to construct the highway originally.

B.2.2 Right of Way Plans

Obtain existing Right of Way plans that show the relationship of the existing right of way to the Public Land Survey System.

B.2.3 Original Survey Books

Retrieve old original survey books from past surveys of the project site.

B.2.4 Courthouse Records

Review courthouse records to investigate recorded monument records and parcel records of adjoining lands to the survey site.

B.2.5 Local Surveyors

Contact local surveyors for information they may have on the public land survey system in the job site area.

B.2.6 Original Government Notes

Obtain copies of the original government survey notes and township plats from the state archives.

B.2.7 Utility Easements

Obtain information on all easements held by utility companies or others.

B.2.8 Aerial Photography/Maps

Obtain a copy of recent aerial photography covering the survey project or USGS 7.5' topographic maps.

B.3 Design Surveys

To perform a design survey, information shall be obtained for the following: existing centerline, proposed centerline, control traverse, bench mark data and the most recent construction plans.

B.3.1 Existing Centerline

Existing centerline is needed to reestablish a base line to use as a reference line for information on projects where there are no plans to alter the existing alignment. The existing centerline may be needed to reestablish the right of way lines. This information is available from old construction plans.

B.3.2 Proposed Centerline

Proposed centerline information is required when alignment changes are proposed along the existing alignment or the alignment covers all new terrain. This information is available from the planning units of IDOT.

B.3.3 Field Books

Field books containing any traverse or vertical work shall be obtained for use in recovering any existing control established on previous surveys.

B.3.4 Monumented Control

Obtain information on monumented control established by the National Geodetic Survey and the U.S. Geological Survey. [See Section B.1.1 and B.1.2, page 1-9.](#)

B.4 Photogrammetric Survey

To perform a photogrammetric survey for design or location purposes, the following information shall be obtained: the limits of the area to be mapped, the targeting requirements and the control monumentation that is available.

B.4.1 Mapping Limits

Obtain the mapping area from the Bureau of Program Development.

B.4.2 Targeting Diagrams

The Aerial Surveys Section provides location diagrams for target placement and/or field guidance through the Aerial Surveys' field crew.

B.4.3 Control Resources

B.4.3.1 National Geodetic Survey (NGS)

[See B.1.1, page 1-9.](#)

B.4.3.2 U.S. Geological Survey (USGS)

[See B.1.2, page 1-9.](#)

B.4.3.3 Illinois Department of Transportation (IDOT)

IDOT files shall be checked to investigate the existence of horizontal and vertical control established by previous IDOT surveys.

B.5 Construction Surveys

To perform a construction survey, a set of new construction plans is needed along with the Right of Way plats and plans. Construction plans shall provide centerline control and bench mark information.

B.5.1 Construction Plans

Construction plans are available from the district construction office.

B.5.2 Right of Way Plats and Plans

Right of Way plats and plans can be acquired from the Land Acquisition Section in the district office.

B.6 Location Surveys

To perform a location survey, topographic maps and/or aerial photographs are used. This type of survey is generally carried out by office planning personnel and very seldom requires the collection of conventional field survey data.

VIII. DEFINITIONS

Definitions of some of the common terms used in surveying in the department are listed below.

Alignment: A series of tangents and curves identifying a centerline for an existing or proposed highway.

Azimuth: The direction of one point or object, with respect to another, where the direction of the line is expressed as the clockwise angle from 0° to 360°

Bar-code Level: A level instrument designed to electronically read a special leveling rod with a bar-code face. Readings are automatically recorded on an electronic data recorder.

Bench Mark: A relatively permanent material object, bearing a marked point whose elevation above or below an adopted datum is known.

Central Angle: The angle at the center of radius of a circular arc included between the radii that pass through the beginning point (P.C.) and the ending point (P.T.) of the arc. Also known as the delta angle.

Coordinate System: A reference system for defining points in space or on a particular surface by means of distances or angles, or both, with relation to designated axes, planes, or surfaces.

Corner, Quarter Section: A corner midway between the controlling section corners, depending on location within the township.

Corner, Section: A corner established at the junction of surveyed section lines established by the USPLS.

Cross-Section: The elevations of the surface of the ground measured along a line perpendicular to the centerline or base line at any given station on the alignment.

Datum: A reference system whereby the position of one point can be directly related to another.

Deflection Angle: The horizontal angle measured from the prolongation of the preceding tangent line, right or left, to the following tangent line.

Digital Terrain Model (DTM): A model of the existing terrain that is developed from elevation data collected with reference to a coordinate system.

Easement: A non-possessing interest held by one person or agency in land of another whereby the first person is accorded partial use of such land for a specific purpose. Easements fall into three broad categories: surface; subsurface; and overhead.

EDMI: An Electronic Distance Measuring Instrument used to measured distances between points by using phase differences between transmitted and returned electromagnetic waves of known frequency and speed.

GPS: The Global Positioning System. The navigational and positioning system that provides location of a position on or above the Earth by a special receiver that interprets signals received simultaneously from several of a constellation of satellites.

Level Circuit: The measurement of elevations commencing on a known elevation point and ending on a known elevation point.

Leveling Rod: A straight rod or bar with a flat face graduated in linear units with zero at the bottom, used in measuring the vertical distance between a point on the ground and the horizontal line of sight of a leveling instrument.

NAD83: The North American Datum of 1983. It is an adjustment of the horizontal coordinate system.

NGS: The National Geodetic Survey.

NGVD29: The National Geodetic Vertical Datum of 1929. The vertical adjustment of 1929 and based on mean sea level as determined by several tide gages over a period of several years.

NAVD88: The North American Vertical Datum of 1988. The vertical adjustment of 1988 after re-leveling work was accomplished on approximately 62,000 miles of leveling lines across the nation.

Photogrammetry: A method of surveying that makes measurements of the ground surface using aerial photographs.

Plats, Right of Way: A plan of a highway improvement showing the old and new highways and the right of way to be acquired.

Point of Curvature (PC): The point where a straight alignment ends and circular alignment begins.

Point of Intersection (PI): The point where the two tangents of a circular curve meet.

Point of Tangency (PT): The point where a circular alignment ends and straight alignment begins.

Point on Tangent (P.O.T.): A point on the tangent line that is used in the projection of the tangent line in a forward direction.

Reference Point: A point set and used at a survey point or alignment point to help reestablish it or recover it during a survey or during construction.

Stationing, Highway: A reference system used in highways to designate the distance from the point of beginning of a highway centerline. Normally a point is labeled at some even interval. Plus stations are used to refer to any intermediate point that lies between two full or even station marks.

Survey Point Code: A numerical code system established by the department to allow the surveyor to collect survey design data by electronic means and use a computer aided drafting system to plot the data.

TBM: A temporary bench mark set on a project and used to control elevations for surveys and construction of a highway project.

Total Station: A survey instrument consisting of a theodolite and an EDM built as a composite unit. Survey data can be recorded directly to an electronic recording device.

Trigonometric Leveling: The determination of differences in elevation using trigonometric procedures with observed vertical angles and measured or computed horizontal or inclined distances.

USGS: The United States Geological Survey.

USPLS: The United States Public Land System. It consists of a set of rules by which boundaries and subdivisions of public lands have been established in the United States. The USPLS is often used for designating the location of a parcel of land.

SUBJECT: F.A. Route _____
(S.B.I. Route _____)
Section _____
_____ County

Address

Salutation

This Department is now making a survey for the improvement of F.A. Route _____ (S.B.I. Route _____) and borings for soil samples may also be taken. Our survey crew is working in your vicinity and will find it necessary to cross the property (owned or leased) by you in order to take the necessary measurements and elevations, and/or borings.

Our personnel have been instructed to consult with you before entering upon your land. I am sure you will find the crew courteous and considerate of your rights and will cause you a minimum of inconvenience.

This work may cause some damage to your property or crops. Should you sustain any damages, however, I can assure you that this Department will reimburse you for your loss.

Very truly yours,

District Engineer

(Figure 1.1)